Brake device for a construction machine

The present invention relates to a brake device for a construction machine, comprising a first brake circuit, which is coupled to a first brake member on a first wheel axle of the machine, a second brake circuit, which is coupled to a second brake member on a second wheel axle of the machine, the said first and second brake circuits being independent of one another, a pressure source for hydraulic oil, which is coupled to the first and second brake circuit, and a brake valve, which is coupled to the first and second brake circuit, the brake valve being designed to control the hydraulic oil from the pressure source to the brake members on the wheel axles.

A construction machine, such as a wheeled loader or a dumper truck, must be equipped with brakes that are suited to the varying characteristics of the machine. In one extreme case a fully loaded machine must be powerfully retarded and in another extreme case the same machine without a load must be gently braked. In order to enable the driver of the machine to handle the machine, the retardation of the machine must feel controllable and manageable under all operating conditions. From an ergonomic standpoint, the force applied to the brake pedal by the driver must be the minimum possible. The control travel of the brake pedal must also be the minimum possible.

The brake systems hitherto fitted on construction machines comprise two or more independent brake circuits, which are controlled by a brake valve. The brake valve is coupled to the brake pedal, which opens the valve when a force is applied by the driver, so that hydraulic oil under pressure flows to brake members, which are arranged on machine wheel axles or wheels. The brake members comprise a piston, which is moved under the pressure of the hydraulic oil and presses a brake lining 7 against a brake disc. When the driver releases the brake pedal the pressure on the

brake piston 5 ceases and the brake lining 7 is moved into an initial position by means of return springs.

When the driver presses the brake pedal, thereby opening the brake valve, it takes a certain time to move the brake piston 5 from the initial position to the position assumed by the brake piston 5 when the brake lining is bearing against the brake disc. This time is called the brake application time. Once the brake piston has reached this latter position the pressurization of the hydraulic oil against the brake piston commences, which leads to a powerful excess pressure surge in the form of a pressure pulse in the hydraulic oil. This excess pressure surge gives rise to a brake shock, that is to say a powerful retardation of the machine in a short time, which the driver experiences as a jerk. The excess pressure surge also results in components of the brake members being exposed to heavy stresses, which among other things generates noise. The jerking and the noise are experienced by the driver of the machine as irritations.

In gentle braking the force on the brake pedal must be slight. If the machine is travelling on an uneven surface, so that the machine jumps and shakes, it becomes difficult for the driver to control the brake device by means of the brake pedal in order to achieve gentle braking. The retardation of the machine will then vary, so that the driver perceives the brake device as difficult to control. In order to achieve good controllability of the brake device, the brake application time must be as short as possible and the excess pressure surge as small as possible. A short brake application time is achieved by means of a large flow of hydraulic oil through the brake valve, but the greater the flow of hydraulic oil, the greater the excess pressure surge becomes.

An object of the present invention is to produce a brake device, which is adapted to the various operating

conditions of a construction machine, so that machine jerking and noise are avoided when braking the machine.

Another object of the invention is to produce a brake device that exhibits little sensitivity in gentle braking.

This is achieved by a brake device of the type specified in the introductory part, in which a limiting element arranged in the first or second brake circuit limits the pressure and/or flow of the hydraulic oil when the brake valve is controlling the hydraulic oil from the pressure source to the brake members on the wheel axles.

The limiting element helps to reduce the braking action on the one wheel axle at the commencement of the braking sequence, which thereby reduces the sensitivity of the brake device. When the driver depresses the brake pedal gently in order to brake gently, only a small flow of hydraulic oil, if any, will occur in the brake circuit that is fitted with the limiting element, while a large flow of hydraulic oil will flow in the brake circuit that is not fitted with a limiting element. Once a certain time has elapsed or once the hydraulic oil pressure has reached a predetermined limit, the pressure applied to the brake member on the wheel axle that had reduced braking action from the outset will increase the braking action on that wheel axle. In the event of emergency-stop braking, for example, all wheel axles of the vehicle will be braked immediately when the driver presses the brake pedal.

The invention will be explained in more detail below with the aid of embodiments shown in the figures attached, in which

Fig. 1 shows the hydraulic pressure as a function of the time taken to activate a known brake device,

Fig. 2 shows a first embodiment of a brake device according to the present invention,

Fig. 3 shows a brake valve for the brake device according to the present invention,

Fig. 4 shows a second embodiment of a brake device according to the present invention,

Fig. 5 shows a third embodiment of a brake device according to the present invention,

Fig. 6 shows a fourth embodiment of a brake device according to the present invention.

Figure 1 contains a graph showing how the hydraulic pressure varies when a known brake device is activated. The horizontal axis gives the time T and the vertical axis gives the pressure P. As stated in the introductory part of the specification, it takes a certain time t1 to move a brake piston from an initial position to a position assumed by the brake piston when a brake lining, against which the brake piston presses, is bearing against a brake disc. When the brake piston is in this latter position the pressurization of the hydraulic oil against the brake piston commences, which leads to a powerful excess pressure surge in the form of a pressure pulse in the hydraulic oil. This pressurization takes place over a period of time t2. The excess pressure surge gives rise to a brake shock, that is to say a powerful retardation of the machine in a short time, which the driver experiences as a jerk. It has also emerged that noise is generated in the brake device as a result of the said excess pressure surge.

Figure 2 shows a first embodiment of a brake device 1 according to the present invention. The brake device 1 comprises a first brake circuit 2, which is coupled to a first brake member 4 on a first wheel axle 6 of a construction machine. The brake member 4 comprises a brake

piston 5 fitted to each wheel, which piston by way of one or more brake linings 7 interacts with a brake disc (not shown) connected to the wheel axle 6. The brake device 1 also comprises a second brake circuit 8, which is coupled to a second brake member 10 on a second wheel axle 12 of the machine. After application of the brake device the first and second brake circuits 2, 8 are independent of one another, which means that the pressure in one circuit 2, 8 does not affect the hydraulic oil pressure in the other circuit 2, 8. If one circuit 2, 8 fails, the construction machine can still be braked by means of the other circuit 2, 8. A pressure source 14 for hydraulic oil is coupled to the first and second brake circuit 2, 8. The pressure source 14 may take the form, for example, of a hydraulic pump and/or one or more hydraulic accumulators (not shown). A brake valve 16 is coupled to the first and second brake circuit 2, 8, which brake valve 16 is designed to control the hydraulic oil from the pressure source 14 to the brake members 4, 10 on the wheel axles 6, 12. A limiting element in the form of a sequence valve 18 is arranged in the second brake circuit 8.

When the brake valve 16 controls the hydraulic oil from the pressure source 14 to the brake members 4, 10 on the wheel axles 6, 12, the sequence valve 18 will limit the hydraulic oil flow to the second brake member 10 if the pressure of the hydraulic oil falls below a predetermined pressure. This limiting may mean that little hydraulic oil, if any, flows through the sequence valve 18. The sequence valve 18 opens when the hydraulic oil pressure reaches a predetermined pressure, so that a large hydraulic oil flow through the sequence valve 18 occurs. The function of the sequence valve 18 can thus be likened to the function of a pressure-relief valve.

When the brake device 1 is activated, the hydraulic oil in the brake members 4, 10 will be drained, which means that the hydraulic oil will flow in the direction away from

the brake members 4, 10 to the brake valve 16 and on to a tank 20. In order to achieve this, a first bypass line 22 is connected over the sequence valve 18, so that hydraulic oil is allowed to bypass the sequence valve 18. A non-return valve 24 is arranged in the first bypass line 22, so that hydraulic oil is prevented from flowing through the first bypass line 22 in the direction towards the second brake member 10.

According to a first embodiment the brake valve 16 comprises a first and second valve 26, 28, which are acted upon by a brake pedal 30. When the brake pedal 30 is depressed, the first and second slide valves 26, 28 are opened, so that hydraulic oil flows from the pressure source 14 towards the first and second brake members 4, 10. It is preferably the pressure in the first brake circuit 2 that influences the opening of the second slide valve 28, which is indicated by a duct 29 between the first brake circuit 2 and the second slide valve 28.

Alternatively, the first and second slide valves 26, 28 together with the sequence valve 18 and the first bypass line 22 with the non-return valve 24 may be replaced by a brake valve 16', as shown in figure 3. The said brake valve 16' comprises a first slide 32, which controls the flow of hydraulic oil in the first brake circuit 2, and a second slide 34, which controls the flow of hydraulic oil in the second brake circuit 8. The first slide 32 is arranged so as to control the second slide 34, so that the second slide 34 opens the second brake circuit 8 when the pressure in the first brake circuit 2 has reached a predetermined pressure. The said predetermined pressure is determined by the spring force of a first spring 36 of the brake valve 16'. The first slide 32 is connected to the brake pedal 30 and when the brake pedal 30 is depressed, the first slide 32 will be displaced in the brake valve 16', so that the first brake circuit 2 is opened. A second spring 38, arranged between the first and second slide 32, 34, ensures that the second

slide 34 is not displaced by the first slide 32 from the outset. When the first slide 32 has been displaced so far that the first circuit 2 has been opened, the hydraulic oil in the first branch line 33 to the circuit 2 will pressurize the space between the slides 32, 34. When the pressure in the first circuit 2 overcomes the force of the first spring 36, which acts on the second slide 34, the second slide 34 will open the second circuit 8. A second branch line 35 in the second circuit 8 carries hydraulic oil to the end of the second slide 34, which faces the first spring 36. When the pressure in the second circuit 8 together with the force from the first spring 36 overcome the pressure in the first circuit 2, the second slide 34 will close the second circuit 8. The pressure in the second circuit 8 will thereby become lower than the pressure in the first circuit 2. The difference between the pressure in the first and second circuit 2, 8 depends upon the magnitude of the spring force of the first spring 36. The first spring 36 will thereby function as a limiting element.

If the brake pedal 30 is only depressed a short way, in order to undertake gentle braking, only the first wheel axle 6 will be braked. When braking harder, the force of the first spring 36 must be overcome, so that both of the brake circuits 2, 8 are opened, which means that both of the wheel axles 6, 12 are braked. If one of the circuits 2, 8 should fail and hydraulic pressure in one of the circuits 2, 8 be absent when the brake device 1 is applied, the brake pedal 30 can be depressed to such a degree that the second spring 38 is compressed, which means that the second slide 34 will also be displaced, so that the second brake circuit 8 is opened.

Figure 4 shows a second embodiment of the invention. In this embodiment a second bypass line 40 is arranged over the sequence valve 18. A restrictor valve 42, which means that a limited flow of hydraulic oil can always bypass the sequence valve 18, is arranged in the second bypass line 40.

By means of the limited hydraulic oil flow, the second brake member 10 will be slowly activated and will brake the second wheel axle 12 by gentle braking when the pressure of the hydraulic oil does not attain the predetermined pressure at which the sequence valve 18 opens. Retarded braking of the second wheel axle 12 is therefore achieved.

According to a third embodiment, which is shown in figure 5, it is feasible to provide only the second brake circuit 8 with a restrictor valve 42', so that retarded braking of the second wheel axle 12 occurs. The restrictor valve 42' here constitutes a limiting element. In this way brake shock is prevented in gentle braking of the machine. It is also feasible, according to a fourth embodiment in figure 6, to arrange the first bypass line 22 with a non-return valve 24 over the restrictor valve 42' in the second brake circuit 8. This achieves rapid draining of the second brake member 10 when the brake device 1 is deactivated.

A brake device 1 with two brake circuits 2, 8 has been descried above. It is possible, however, to design the brake device 1 with three or more brake circuits. It is also possible to arrange the limiting element 18, 42' in the first brake circuit 2 rather than the second brake circuit 8. The first wheel axle 6 may be a front axle and the second wheel axle 12 may be a rear axle of the machine, or vice versa.